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Habitat Use and Movements of Rocky Mountain Elk on the Peace Arm of Williston Reservoir, 1991-1994

R. J. Backmeyer
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The Peace/Williston Fish & Wildlife Compensation Program is a cooperative venture of BC Hydro and the provincial fish and wildlife management agencies, supported by funding from BC Hydro. The Program was established to enhance and protect fish and wildlife resources affected by the construction of the W.A.C. Bennett and Peace Canyon dams on the Peace River, and the subsequent creation of the Williston and Dinosaur Reservoirs.

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EXECUTIVE SUMMARY

In 1985, B.C. Environment, in cooperation with the Hudson's Hope Rod and Gun Club, initiated an elk transplant project to augment a small native herd residing on under-utilized, high-quality habitat along the north shore of the Peace Arm of Williston Reservoir. Between 1985 and 1987, 145 elk were transplanted from the East Kootenays to a release site near Dunlevy Lake. Prescribed fire was used to enhance pockets of class 2 and 3 winter range in the transplant area in 1986 and 1990.

The Peace/Williston Fish and Wildlife Compensation Program initiated the Peace Arm Elk Study in 1991 to determine seasonal habitat use and movements of transplanted elk, and assess the potential for future habitat enhancement. A number of aspects of elk habitat use were examined, including: seasonal habitat selection, seasonal movements, and home range size. Five cow elk from the core area, between Butler Ridge and Adams Creek, were fitted with VHF radio-collars. Monthly radio-telemetry flights were conducted, using a fixed-wing aircraft, from March 1991 through May 1994.

Although the Peace Arm Elk Study was not designed to measure the overall effectiveness of the transplant, observations made during telemetry flights support preliminary B.C. Environment findings that the introduced elk were successfully recolonizing suitable habitats along the north shore of the Peace Arm, as well as vacant lands to the north and west. An identified core area, which provides critical winter range to the Peace Arm elk herd, should be protected, maintained, and enhanced, to insure the long-term viability of the population.

Management recommendations and suggestions for further research include:

- protection of the core area from alienation, resource extraction and access development,
- continued enhancement and maintenance of the open shrub/grassland habitat type in the core area,
- implementation of an elk telemetry study outside the boundaries of the core area. Although this recommendation is suggested to gather further information on habitat use and movements of the Peace Arm elk herd, it should be noted that it is beyond the mandate of the Peace/Williston Fish and Wildlife Compensation Program.

This report was originally submitted in July 1994. A revised version was completed May 2000, incorporating comments from a review panel of B.C. Environment and B.C. Hydro wildlife biologists. Recommendations made in the 1994 draft have been modified to reflect current conditions.

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1.0 INTRODUCTION

Rocky Mountain elk *(Cervus elaphus nelsoni) are* native to the Peace River area, but disappeared in the late 1800's, apparently after a series of extremely severe winters (Peck 1987, Harper 1988). Elk have slowly repopulated the area from refugia located to the southeast, in Alberta, and the Muskwa River area, to the north. A small herd, of less than 20 animals, was known to inhabit the north shore of the Peace Arm of Williston Reservoir in the late 1970's and early 1980's (Churchill 1987), but recruitment in the isolated population was low. At that time, the habitat was estimated to be capable of supporting approximately 400 elk, with the possibility of increasing the carrying capacity to 800 animals through enhancement.

A transplant was initiated in 1985 to supplement the existing herd and establish a viable population. In February and March of 1985, 107 elk were transplanted from the East Kootenays to a release site near Dunlevy Lake (Tipper 1985; Churchill 1987). This herd was supplemented with an additional 38 elk from the East Kootenay's in February 1987 (Harper 1987). Prescribed fire has been used to enhance pockets of class 2 and 3 elk winter range along the north shore of Williston Reservoir. Burns were carried out in 1986 and 1990. Subsequent to the first elk introduction, the Wildlife Branch used various methods to monitor the progress of the animals, including incidental sighting reports from members of the public, particularly the Hudson Hope Rod and Gun Club (Churchill 1987). By the summer of 1985, ear-tagged elk had been seen as far north as the Graham River watershed. An aerial census, conducted in March 2000, counted 382 elk on the core winter range between Gravelhill and Aylard Creeks. A total of 448 elk were counted between Bullhead Mountain and the Nabesche River (Wood, IN PREP).

The Peace/Williston Fish and Wildlife Compensation Program initiated the Peace Arm Elk Study to determine seasonal habitat use and movements of the transplanted elk, and assess the potential for future habitat enhancement. The study considered several aspects of elk use including: seasonal habitat selection, seasonal movements, and home range size. Five cow elk from the core herd, which was defined as those animals wintering along the north shore of Williston Reservoir, between Butler Ridge and Adams Creek, were radio-collared in 1991. Monthly radio-telemetry flights were conducted from a fixed-wing aircraft from March 1991 through May 1994.

2.0 STUDY AREA

The study area lies north of the Peace Arm of Williston Reservoir, extending from the Nabesche River east to Butler Ridge and north to the Graham River and Emerslund Lakes (Fig. 1). Within this larger zone, a "core area" of high-quality ungulate winter range, in close proximity to the original introduction site, was delineated as the north shore of the Peace Arm, between Butler Ridge and Adams Creek. The core area is characterized by steep, south-aspect, shrub/grassland "breaks" bordered by mature deciduous, mixedwood and conifer forests, which provide thermal and security cover.

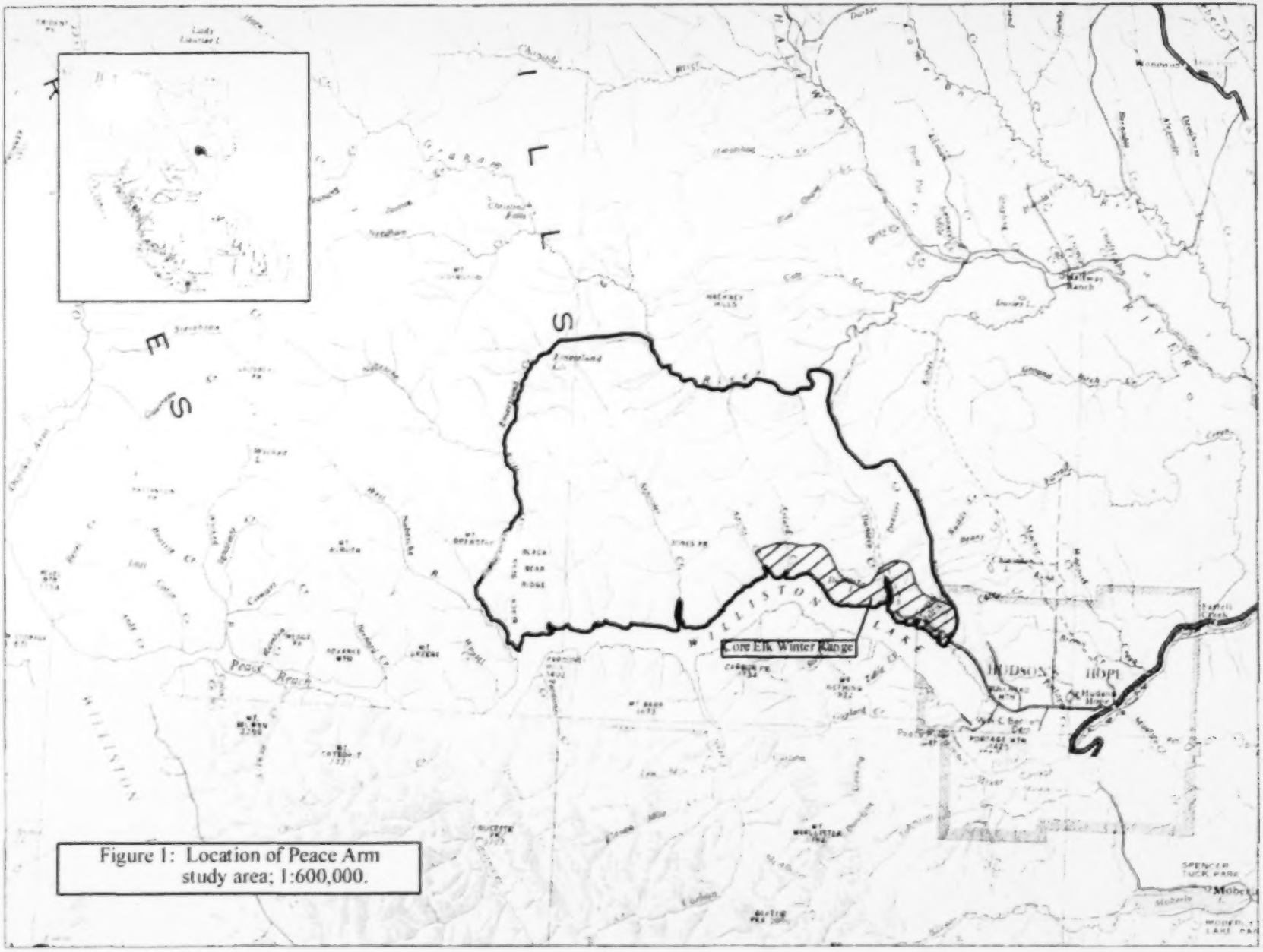

Figure 1: Location of Peace Arm study area; 1:600,000.

The entire study area is within the Peace Foothills ecosection, which is comprised of a series of north/south ridges bisected by major river valleys. Elevation ranges from 660 metres along Williston Reservoir to 1880 metres on Aylard Ridge. Precipitation within the study area is variable with the western portion receiving considerably more rainfall and snow accumulations due to the proximity of mountain ranges to the west. The eastern portion is much drier, with an increased rain shadow effect as distance from the mountains increases. Warm, southwest "Chinook" winds commonly reduce winter snow accumulations along Williston Reservoir as Pacific air flows through the low elevation pass formed by the Peace Arm.

All elk radio-telemetry locations made during the study were situated in the southern half of the study area (map sheets 94B/1 and 94B/2). Detailed biophysical mapping of the area encompassed by these mapsheets was completed in 1993. This portion of the study area includes five biogeoclimatic zone variants as described in Thompson (1993).

Table 1: Description of biogeoclimatic zone variants found in the southern portion of the study area.

Biogeoclimatic Zone/Variant	Description
BWBSmwl	**Moist warm Boreal White and Black Spruce:** This unit is the driest in the study area and is found only at the lowest elevations east of Dunlevy Inlet. It generally has high ungulate winter capability; elk, moose, mule deer, white-tailed deer and Stone's sheep all winter in this unit.
BWBSwkl	**Wet cool Boreal White and Black Spruce:** This unit differs from the mw1 due to increased precipitation and decreased mean temperature. It is found at low elevations along Williston Reservoir and contains the majority of ungulate winter range within the study area.
ESSFmv2	**Moist very cold Engelmann Spruce Subalpine Fir:** This is the drier of the upper elevation conifer forests and is found mainly on the ridges in the eastern portion of the study area.
ESSFmv4	**Moist very cold Engelmann Spruce Subalpine Fir:** This unit is the wetter of the upper elevation conifer forests that are predominant in the western portion of the study area.
AT	**Alpine Tundra:** This unit occurs on ridges and peaks over 1500 metres throughout the study area.

3.0 METHODS

3.1 Capture, Collaring, and Radio-telemetry

Mature cow elk were selected for telemetry to avoid loss of collared animals through juvenile dispersal, and the logistical difficulties associated with capturing mature, antlered bulls.

Elk were captured using a net gun fired from a Bell 206B helicopter. Rob Woods, B.C. Environment wildlife technician (Fort St. John), carried out all net gunning, with

additional manpower provided by local volunteers. Once netted, elk were restrained, hobbled and blindfolded by a 2-3 person crew. This approach eliminated the need for immobilizing drugs, allowed for immediate release after collaring, and presumably reduced stress on individual animals. Each animal was ear-tagged and fitted with an LMRT-4 radio-collar with mortality option (Lotek Engineering Ltd., Newmarket, ON).

Collared elk were located at roughly monthly intervals (weather permitting) using a Cessna 172 fixed-wing aircraft, equipped with two wing-mounted antennae. During each flight, locations were plotted onto 1:50,000 NTS maps or 1:50,000 air photo mosaics. Additional information recorded for each location included time, weather conditions, specific habitat used, counts and classification of animals observed. Further details were determined from topographic maps in the office, including: Universal Transverse Mercator (UTM) grid, elevation, percent slope, and aspect. Similar information was also recorded for all incidental sightings of non-collared animals.

3.2 Seasonal Habitat Use

Seasonal habitat use was determined for five periods, which were delineated on the basis of similar habitat use (Table 2). Although foraging activities may be comparable during summer and fall, habitat selection might be associated with other factors, such as predator avoidance behaviour of cows with newborn calves or the occurrence of the annual rut. Similarly, there may be differences in habitat use between the early and late winter periods related to snow accumulation or Chinooks.

Table 2: Description of seasonal habitat use periods delineated for the Peace Arm Elk Study.

Season	Description
Early winter (Nov/Dec/Jan)	Includes the majority of snow accumulations and cold weather conditions
Late winter (Feb/Mar/April)	Includes most Chinook events and spring green-up.
Calving (May/June)	Encompasses calving site selection, calving and approximately 2-3 weeks of post-calving hiding (Geist 1982).
Summer (July/Aug)	Includes the summer nursery herd period.
Fall (Sept/Oct)	Encompasses the rut season and the open hunting season.

Habitat types were divided into four categories of distinct vegetative associations: *shrub/grassland, deciduous forests, mixedwood forests, and conifer forests* (Table 3). All groupings were determined by reviewing the vegetative associations and successional stages described by Thompson (1993).

Location data was transferred from the 1:50,000 NTS field-maps to 1:50,000 biophysical vegetation maps to determine habitat use. All radio-telemetry locations for collared elk were within the area covered by the 1993 biophysical mapping project. In order to standardize the habitat selection methodology, habitat types used were determined from the vegetation maps. As flight-report forest cover classifications were based on visual evaluation by the spotter and subject to personal bias, the original flight-record classifications were not employed.

The original study design was aimed at determining general trends in habitat use. The small number of animals collared was not expected to provide statistically valid data. Presuming that all scheduled relocation flights occurred and elk were located each time, approximately 40 data points per animal could be obtained over the course of the study. Keeton (1972) suggests a minimum of 50 locations per animal is required to provide a reasonable level of statistical significance.

Table 3: Description of habitat types found in the study area.

Habitat Type	Description
Shrub/grassland	Includes all sites that are predominantly grass producers and are exposed to significant solar radiation and winds. This category includes shrub/grassland associations, immature aspen types, cultivated fields, meadows and NSR (not satisfactory restocked) burns. The majority of shrub-grassland habitat within the study area is concentrated on south-aspect slopes.
Deciduous Forests	Includes all aspen and poplar types with a minimal conifer component.
Mixedwood Forests	Includes any forest with both the conifer and deciduous components.
Conifer Forests	Includes all conifer types with minimal deciduous component.

Derived from Thompson (1993)

3.3 Seasonal Movements

Two aspects of seasonal movements were considered:

- Seasonal movements relative to elevation were examined using the categories described in Table 2: early winter, late winter, calving, summer, and fall. Elevations for each location were grouped by season and averaged. The results for each collared elk were graphed to determine trends.

- A comparison of summer versus winter locations was also made. All locations were grouped into two categories and plotted on 1:50,000 NTS mapping: summer (May-October), which included the habitat use periods of calving, summer, and fall, and winter (November-April). The criteria for describing individual animals as migratory or non-migratory was as follows: elk showing a

distinct separation between summer and winter ranges were considered migratory; while those with overlapping seasonal ranges were considered resident (Adams 1982).

3.4 Home Ranges

Multi-year home ranges were determined for each collared elk by plotting all U.T.M, coordinates onto 1:50,000 NTS maps. Minimum convex polygons were delineated by connecting peripheral location points with straight lines (Mohr 1947). In situations where the home range included significant portions of Williston Reservoir, the reservoir was deleted from the home range calculations. Home range sizes were calculated with a digital planimeter.

4.0 RESULTS

4.1 Capture, Collaring, and Radio-telemetry

Five elk were captured and radio-collared in March 1991. Capture and collaring details, including radio frequency and ear-tag descriptions, are summarized in Appendix I. Two mature adult and 3 young adult cows were fitted with collars. The former were both previously tagged, indicating they had been part of the initial transplant population. All captured elk appeared to be in good condition.

Four additional capture attempts were unsuccessful. The 4 unsuccessful captures were attempted on March 2, 1991: 2 on the point east of Aylard Creek, a third near Mahaffy Cliffs, and 1 near Folded Hill Creek. The intent was to collar elk using habitats beyond the core winter range, but net-gunning operations were hampered in the western half of the study area by a lack of open habitat.

Radio-telemetry flights were conducted on a monthly basis, with additional flights during the spring and fall of 1991. Forty-four monitoring flights were made, with 174 locations documented between March 1991-May 1994 (Appendices II and III). Three of the 5 collared elk survived for the full 38-month monitoring period, 1 was shot after 12 months, and the fifth disappeared after 22 months (Table 4). In the latter case it was not known whether the failure to relocate this animal was due to radio-transmitter malfunction or migration beyond the boundary of the monitoring area. A third possibility is that the animal was shot and the collar destroyed.

Table 4: Monitoring duration and frequency of observations of radio-collared elk in the Peace Arm Elk Study.

Collar Frequency*	Capture Date (dd/mm/yr)	Last Location (dd/mm/yr)	Months Monitored	Total# Locations	Status
148.505	02/03/91	26/05/94	38	42	Transmitting
148.545	02/03/91	09/01/93	22	29	Missing
148.565	02/03/91	26/05/94	38	41	Transmitting
148.445	16/03/91	14/03/92	12	20	Shot
148.585	16/03/91	26/05/94	38	42	Transmitting

*Collar frequencies may be recorded on data sheets ± .003 due to frequency drift associated with changes in temperature.

4.2 Seasonal Habitat Use

Data on seasonal habitat use are presented in Figure 2. Habitat use was concentrated along the south-southwest aspect breaks bordering Williston Reservoir (Fig. 3). Habitat diversity within this core area is high, with shrub/grassland, deciduous forests, mixedwood forests, and conifer forests all readily available. With the exception of conifer forests in winter, all habitat types were used, to varying degrees, during all seasons.

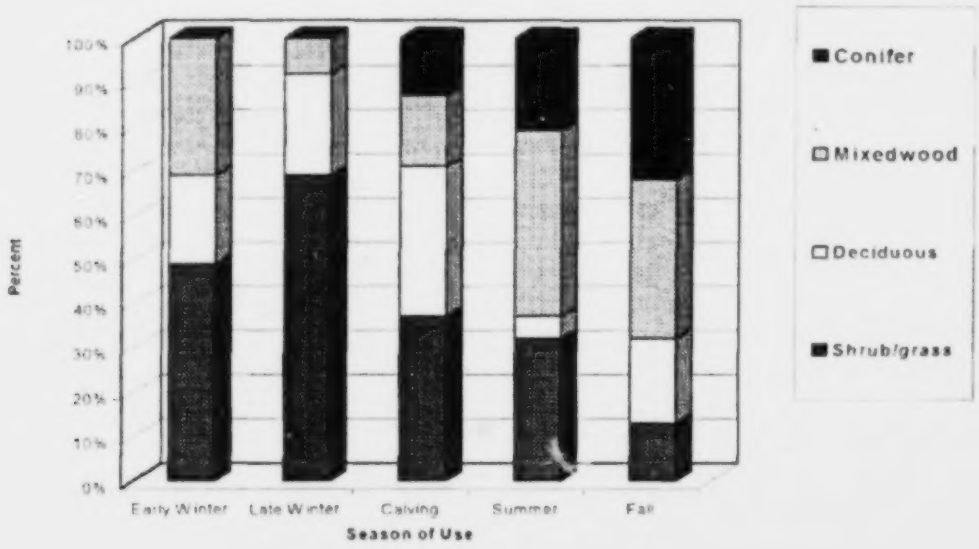

Figure 2: Seasonal use by habitat type of radio-collared elk on the Peace Arm of Williston Reservoir, (n = 174).

Table 5 compares seasonal habitat selection to availability of the four habitat types. The data suggests a strong preference for shrub/grassland habitat by elk in early and late winter. During calving season the majority of locations (71 %) were in

Figure 3: Summer versus winter locations of collared elk; 1:50,000 NTS.

○ summer

● winter

shrub/grassland and deciduous habitats. There was a marked avoidance of conifer habitat in early and late winter. Although the mixedwood type is selected frequently in early winter, there appears to be a shift away from this habitat in late winter. Aside from the limited use of deciduous habitat in summer (1 location), there appears to be no significant selection or avoidance of specific habitats in summer and fall.

Table 5: Elk habitat selection compared to availability of habitat type.

Season	Locations By Habitat Type							
	Shrub/grassland		Deciduous		Mixedwood		Conifer	
	% Locations (Actual)	% Avail.	% Locations (Actual)	% Avail.	% Locations	% Avail.	% Locations (Actual)	% Avail.
Early Winter (n=39)	49 (19)	19.31	20 (8)	13.56	31 (12)	36.29	0 (0)	30.84
Late Winter (n=47)	68 (32)		23 (11)		9 (4)		0 (0)	
Calving (n=38)	37 (14)		34 (13)		16 (6)		13 (5)	
Summer (n=19)	32 (6)		5 (1)		42 (8)		21 (4)	
Fall (n=31)	13 (4)		19 (6)		36 (11)		32 (10)	

The following excerpt is taken verbatim from an interim technical report written after the completion of the first year of monitoring (Backmeyer 1992). The observations made at that time were particularly relevant as all five elk were still transmitting signals.

> *Relocations during this [calving] period were primarily made in dense aspen and mixedwood cover just above open south-aspects. Some relocations were made in shrub/grassland habitat, but these animals were never accompanied by calves. These cows may have been without calves or their calves may have been hidden while they were feeding on open slopes.*
>
> *By June 25th nursery herds were back onto the open slopes where they remained until August.*

All of the collared elk underwent their greatest movements during the period from mid-August to October, typically moving into thick mixedwood or coniferous cover. Four of the animals moved into cover at higher elevations while the other remained in thick, immature pine, just above the open slopes. These movements may have been rut related or a result of hunting pressure.

November found all collared elk back on or near low elevation open slopes where they remained throughout the winter. All five elk were relatively mobile during the winter period, moving several kilometres back and forth along the open south aspects.

4.3 Seasonal Movements

All collared elk appeared to be resident animals, with no major migrations between distinct seasonal ranges. Seasonal movements seemed to be related to habitat selection and avoidance. Summer locations were dispersed throughout the home ranges, while winter locations were concentrated on or near shrub/grassland habitat. There was a consistent shift from low-elevation open habitats in winter to higher elevation forested habitats in summer and fall (Fig. 4).

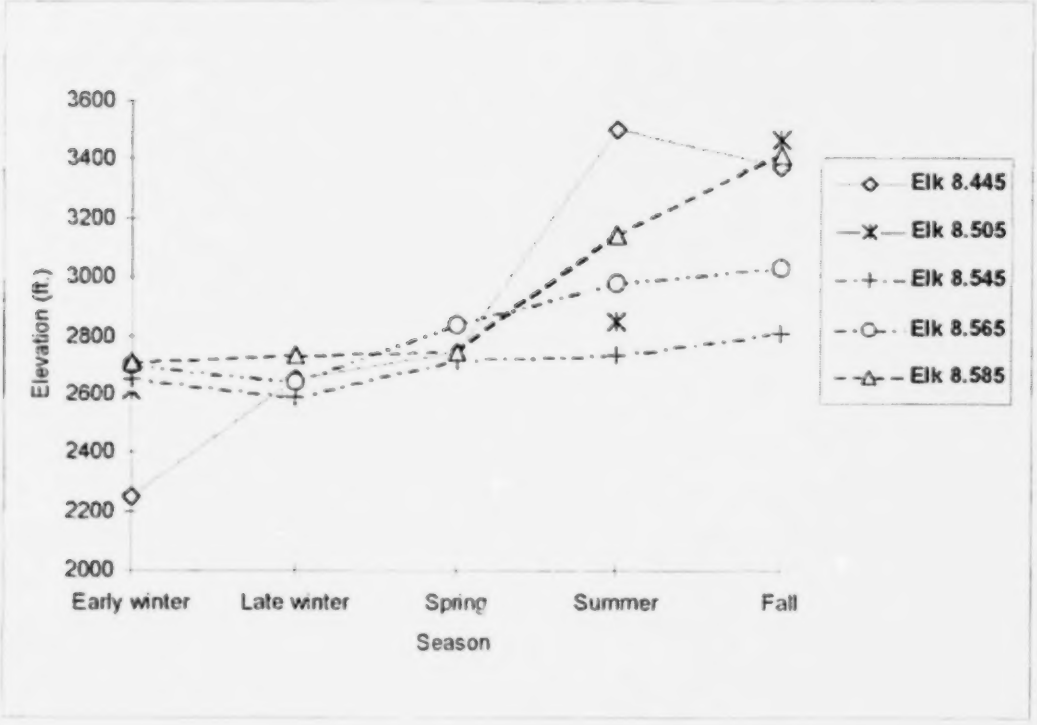

Figure 4: Mean elevation of Peace Arm radio-collared elk by season.

4.4 Home Ranges

Home range sizes were relatively small; ranging from 23.3 km^2 to 41.5 km^2, with a mean of 31.2 km^2 (Table 6, Fig. 5). Home range polygons for Elk 148.505 and Elk 148.545 included large portions of Williston Reservoir; the reservoir area was deleted from the area calculation of the size of these home ranges.

Table 6: Home range sizes of radio-collared elk on Peace Arm of Williston Reservoir.

Collar frequency	# of Locations	Home range size* (km^2)
148.445	20	23.4
148.505	42	35.0
148.545	29	32.7
148.565	41	23.3
148.585	42	41.5

*Home range sizes for Elk 148.505 and Elk 148.545 have been adjusted to delete areas within reservoir.

5.0 DISCUSSION

The selection of mature cow elk, combined with the small sample size, may have resulted in data that are not representative of the general elk population on the Peace Arm. Habitat selection, seasonal movements and home ranges for bulls or dispersing juveniles may vary significantly.

5.1 Capture, Collaring, and Telemetry

All captures were performed using a hand-held net gun, fired from a Bell 206B helicopter. Possible alternatives included the use of a corral trap or dart gun. A corral trap was not practical due to the lack of access. The use of darts was rejected as the delay before the drugs take effect could result in a darted animal travelling considerable distances or succumbing in inaccessible terrain. As helicopter support was required for both methods the costs of darting and net gunning were comparable.

Relocation flights were conducted from a chartered 172 Cessna. The results were adequate, although the 172 proved to be somewhat underpowered in rough weather conditions in the mountains. As a result, some scheduled flights were postponed or cancelled. At the time of the study, there was no suitable alternative fixed-wing aircraft available for charter in Fort St. John. The use of helicopters would have greatly increased the cost of monitoring.

5.2 Seasonal Habitat Use

The five cow elk in this study showed a marked preference (58.6%) for shrub/grassland habitats during winter months. This is consistent with results from the Peace River Site C study, 60 km to the east, which documented a 58.1 % use of south aspect river breaks

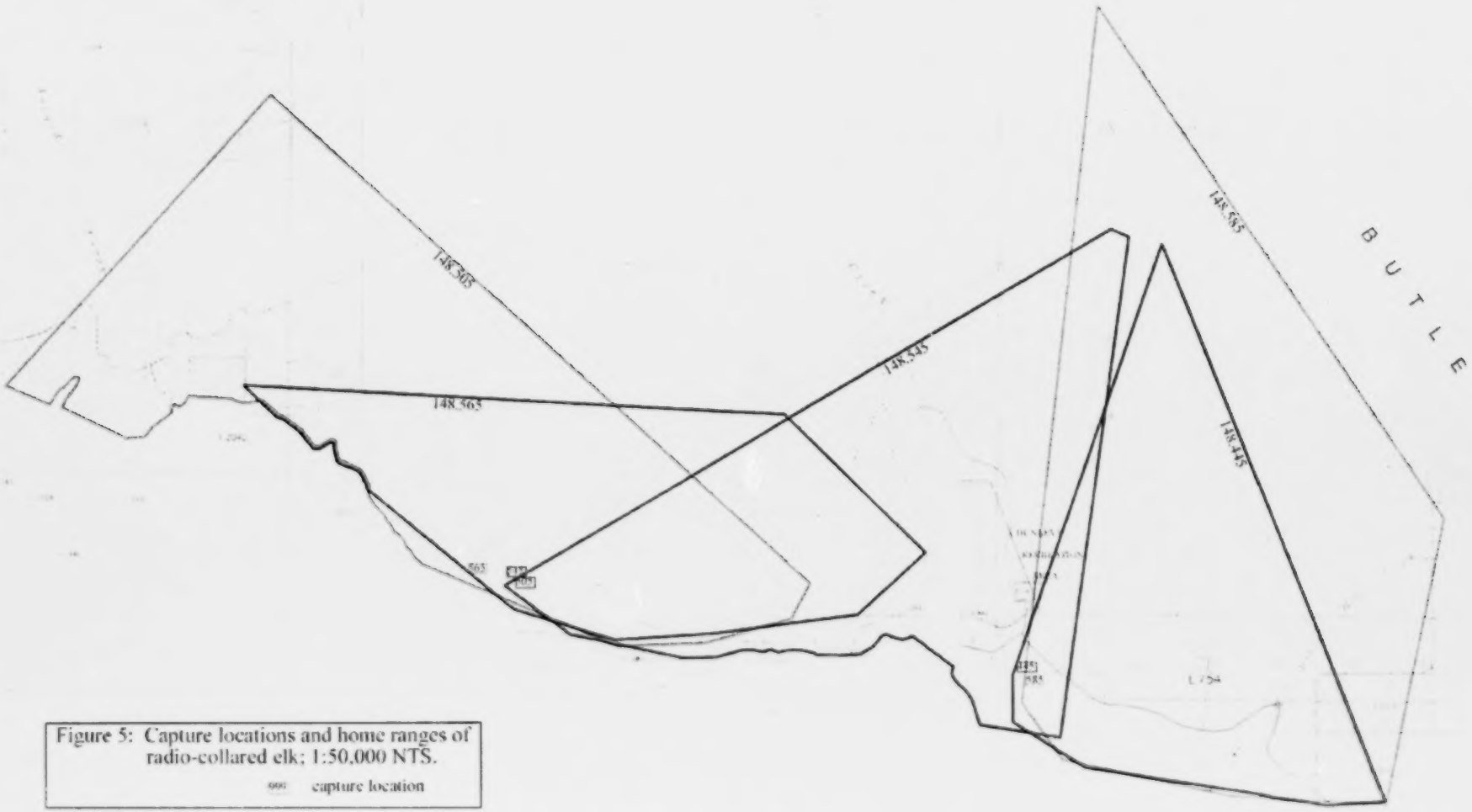

Figure 5: Capture locations and home ranges of radio-collared elk; 1:50,000 NTS.

999 capture location

and cultivated fields (Simpson 1993). The Site C habitat descriptions correspond closely to the habitat designations used in the Peace Arm Elk Study. Although the small sample size must be taken into consideration, the obvious selection of shrub/grassland habitat and apparent avoidance of conifer and mixedwood forests in winter may result in a high concentration of elk within a restricted area. The selection of shrub/grassland habitat appears to be related to forage availability; the lack of tree canopy combined with the southerly aspect result in rapid loss of snow cover during Chinook events. The Branham Slide area, immediately west of the core winter range, has similar aspect and slope but is dominated by mature aspen forests that retain snow cover throughout the winter. Elk winter in the Branham Slide area, but densities are much lower than on the core winter range.

Although the data suggests mature conifer habitat is not used in winter, this may be partly due to the inherent bias in tracking VHS collars by aircraft. Relocation flights are only possible during fair weather; any use of habitats that provide thermal cover during heavy snow or high winds would not be captured. Similarly, habitat selection for night bedding sites would not be determined using conventional aerial monitoring methods.

Approximately 19% of home ranges of the collared elk are classed as shrub/grassland habitat. An estimated 200-250 elk currently use this habitat type as winter range (Churchill, pers. *comm.)*. It is not known if this number represents a predominantly resident population or if some elk migrate north and west in the summer and return to the core area to winter. Regardless of the extent of the summer ranges, it is essential that the core winter range be maintained or enhanced if this population is to remain healthy. The use of prescribed fire has been shown to have a positive effect on elk populations in northeastern B.C. (Backmeyer et al. 1992). Prescribed fires were used in 1986 and 1990 to maintain shrub/grassland habitat on the core area winter range. Habitat enhancement burns have also been carried out on either side of the core area, specifically, Branham Slide to the east in 1993, and the Butler Ridge area to the west in 1994.

It is important that habitat enhancement programs consider all aspects of elk habitat requirements. Martinka (1976) concluded that extensive burned areas lacking in sufficient cover do not support high densities of wintering elk. The strong selection of deciduous forests during calving also has implications for prescribed burning. Any burn proposals must be relatively small and very site specific in order to insure the retention of a high degree of habitat diversity. Restricting the size of prescribed burns to create a mosaic of varied habitats would also benefit non-target species. There is strong anecdotal evidence to suggest prescribed burning of potential elk winter ranges outside of core wintering areas has resulted in rapid colonization in other sites in the Peace River Sub-region (Backmeyer et al. 1992).

Had attempts to collar animals wintering beyond the core area been successful other important wintering sites may have been identified.

5.3 Seasonal Movements

Some non-migratory elk may make seasonal movements in response to forage conditions or disturbance. Movements in response to forage conditions resemble migrations in that they are generally to higher elevations in the summer and lower elevations in the winter as elk seek out more palatable vegetation (Adams 1982). Data from the Peace Arm Elk Study is consistent with this pattern. Adams suggests seasonal use is determined largely by forage availability, thermal cover and cover type. A review of Thompson (1993) shows a high degree of habitat diversity in the mixedwood forests and in immature conifer forests. Data from this study show no significant selection of habitats in summer and fall. This may be attributed to the mosaic of cover types, ranging from pure deciduous through pure conifer, that are found on a micro-site basis within the mixedwood and immature conifer forests.

The excerpt included in Section 4.2 suggests movements were linked to the selection of specific habitat characteristics, such as the availability of security cover adjacent to forage, particularly during the post-calving period and rut. It is interesting to note that all five elk made frequent forays of several kilometres at a time, across the south-aspect winter range, which implies highly mobile habits. This compares to summer movements, which generally remained within a few kilometres of the core area. Elk 8.505 had one summer location approximately 4 km north of the south-aspect breaks used in winter, while Elk 8.585 was located one time approximately 8 km from the lake. Although the study design did not specify a minimum distance to describe migratory versus non-migratory animals, these movements would not appear to be migrations as the animals did not make specific movements to an area and remain there for any length of time. The elk did not make appreciably larger movements on open summer range than on the restricted winter range.

Snow depth may be the most limiting factor to elk distribution and movement. Adams (1982) states that movement begins to be restricted at snow depths of 41-46 cm, triggering a shift to lower elevations. Once snow depths exceed 61 cm elk are generally restricted to conifer forests with a high snow interception capability. Adams also suggests that at snow depths over 61 cm elk foraging shifts from herbaceous to woody material. Elk in the Peace Arm study appeared to select against conifer forests in winter, which suggests snow depth may not typically be a limiting factor in this area. Once again, caution must be used when interpreting these data. Snow depth measurements were not recorded during the study, and there is no detailed, historical snow depth data available for the core wintering area identified in this report. Personal observations by local wildlife management personnel indicate snow depths increase rapidly with increased elevation and are considerably higher in the western portion of the study area.

5.4 Home Ranges

The five elk collared in this project appeared to be non-migratory, with no distinct separation of seasonal ranges, and an average home range of 31.2 km^2. The Peace River Site C study (Simpson 1993) monitored 8 cow elk, with an average home range of 125 km^2. The Site C elk with the smallest home range (36.7 km^2) was non-migratory; the remaining 7 were migratory with seasonal movements of 15 to 20 km. The limited data from the Peace Arm Elk Study indicates a non-migratory population, however, there have been documented sightings of ear-tagged elk, from the 1985 and 1987 transplants, throughout the Peace Arm area and north to the Graham River drainage. Since the 1985 transplant, elk have been observed wintering in the Graham River valley (Watson pers, *comm.),* however, it is not known if there is seasonal movement between the Peace Arm herd and the Graham herd.

The opening of the bull elk hunting-season in 1990 resulted in further documentation of elk dispersal and raised questions regarding the availability of winter range beyond the core area. During the elk seasons from 1990 through 1993, ear tagged bulls were harvested within the core area (4), in the Chowade River area (1), in the Graham River area (1), and one ear-tagged cow was harvested by a native in the Akie drainage. Bull elk were also harvested in the vicinity of the Nabesche River. Some of these locations may have been the result of juvenile dispersal, however, elk in the Graham and Nabesche watersheds may be migratory animals that return to the core area to winter.

The scope of this study was not sufficient to definitively assess the migratory behaviour of the Peace Arm elk population.

6.0 RECOMMENDATIONS

The core area of habitat, extending along the north shore of Williston Reservoir from Butler Ridge to Adams Creek, provides critical south-aspect shrub/grassland winter range for the Peace Arm elk population. It is important that this area be protected, maintained and enhanced if this elk herd is to remain viable. A number of information gaps should be addressed in order to properly manage elk found in the peripheral areas, namely west of Adams Creek and the upper Dunlevy Creek/Graham River watersheds.

The following recommendations, which are included to provide options for future management and research opportunities, are made in order of priority:

- Protect the core area (Butler Ridge to Adams Creek) from alienation, resource extraction and access development. There should be no new access, including roads and seismic trails, created within the critical core area. In order to achieve these objectives, a detailed management plan should be drafted. The involvement of all stakeholders, including government agencies, industry, First Nations, and special

interest groups should be sought in the development of the plan. Current developments highlight the need for habitat protection measures to be taken:

> Recent initiatives promoting commercial backcountry recreation have spurred much interest. There are presently a number of proposals submitted for commercial licences to develop horseback riding, heli-niking and heli-skiing operations on the Peace Arm. Some of these applications include tenure, in the form of long-term leases, to build lodging on Crown Land. Both forest industry and petroleum developments are encroaching on the habitat north of Williston Reservoir. Proposed forestry activity in the Graham River watershed extends south to encompass lands within, and immediately adjacent to, the Peace Arm core winter range, including the headwaters of Dunlevy Creek. Road development into proposed cutblocks and lease sites would serve to fragment large tracts of wilderness and provide access into areas of critical ungulate winter range. This may result in increased hunting pressure on the Peace Arm elk herd, which is currently only accessible from north shore of the lake.
>
> The old "Powell" property (Lot 3181) has recently been purchased by private interests. Although this deeded land has been left vacant for years, and is barely distinguishable from the surrounding Crown Land, it may be presumed that the new owners might wish to develop it in some manner. Resource management agencies should be prepared to address future applications for road access.

- Continue enhancement and maintenance of the open habitat type in the core area. A detailed management plan should be developed to identify small, site-specific treatment areas and long-term protection areas. It is important that a mosaic of habitat types remain available throughout the core area to provide all habitat components required by elk and to address the need for biodiversity.

- Continue habitat enhancement using prescribed fire on potential winter range in peripheral areas to expand the wintering area and reduce pressure on the core range. The areas that should be considered are Branham Slide, upper Dunlevy Creek, and Bullhead Mountain. Each of these sites is dominated by mature aspen forests that do not provide the winter forage or snow-free conditions found in shrub/grassland habitats. The use of prescribed fire would return portions of these sites to early seral shrub/grassland complexes, thereby expanding the winter habitat available to elk in the area. Although the size of the elk population has not yet reached the estimated carrying capacity of the core winter range, extending the habitat-enhancement prescribed burning program may encourage further exploratory movements into vacant habitats, and the creation of satellite elk populations beyond the core area. In view of the increased industrial and recreational developments mentioned above, the recommendation to enhance

winter range beyond the core area between Butler Ridge and Adams Creeks is warrented.

- Initiate an elk telemetry study outside of the core area. It is not known if elk using lands to the north and west are non-migratory or migratory. Snow accumulations in these areas exceed those of the core winter range; elk may be forced to move to areas of lower snow accumulation or they may have different wintering strategies. Such strategies may involve wintering in conifer stands where thick canopy cover effectively reduces snow accumulations on the ground. Information on elk habitat use and movements in outlying areas is required to delineate and protect other critical winter ranges. The new study should include 5-10 elk west of Adams Creek and 5-10 elk in the upper Dunlevy Creek and Graham River watersheds. The study should be designed to document movements of all segments of the population, including dispersing juveniles and mature bulls. It should be noted that the Graham River drainage is beyond the mandate of the Peace/Williston Fish and Wildlife Compensation Program; this project may best be undertaken in cooperation with B.C. Environment or other agencies.

- Conduct a preliminary evaluation of elk wintering strategies through a detailed pellet collection and diet analysis project or a series of aerial surveys.

- Initiate a program of snow data collection on potential winter ranges in the Peace Arm. Current information on snow accumulation is required to make management decisions regarding winter range potential and enhancement options.

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8.0 PERSONAL COMMUNICATIONS

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APPENDICES I - III

Appendix I: Elk capture and radio-collaring results.

Capture Date	Capture Location	Collar Frequency	Ear Tag		
			Ear	#	Colour
02/03/91	Dunlevy Lake	148.504	R	234	Blue
02/03/91	Dunlevy Lake	148.545	R	397	White
02/03/91	Dunlevy Lake	148.564*	R	98	Red
02/16/91	Tompkins Field	148.445	R	399	White
02/16/91	Tompkins Field	148.584**	R	313	White
			L	21	Red**

* Ear tagged from 1985 transplant (#50 blue). Tag torn out during capture.

** Ear tagged from 1987 transplant (#21 red)

Appendix II: Relocation dates by individual elk.

Date (dd/mm/yr)	Relocations				
	Elk 445	Elk 504	Elk 545	Elk 564	Elk 584
02/03/91		Capture	Capture	Capture	
05/03/91	-	Y	Y	Y	-
16/03/91	Capture	-	-	-	Capture
19/03/91	Y	Y	Y	Y	Y
02/05/91	Y	Y	Y	Y	Y
15/05/91	Y	Y	Y	Y	Y
29/05/91	Y	Y	Y	Y	Y
10/06/91	Y	Y	Y	Y	Y
25/06/91	Y	Y	Y	Y	Y
11/07/91	Y	Y	Y	Y	Y
19/08/91	Y	Y	Y	Y	Y
26/09/91	Y	Y	Y	Y	Y
08/10/91	Y	Y	Y	Y	Y
17/10/91	Y	Y	Y	Y	Y
29/10/91	Y	Y	Y	Y	Y
14/11/91	Y	Y	Y	Y	Y
26/11/91	Y	Y	Y	Y	Y
13/12/91	Y	Y	Y	Y	Y
28/12/91	Y	Y	Y	Y	Y
03/02/92	Y	Y	Y	Y	Y
20/02/92	Y	Y	Y	Y	Y
14/03/92	Y	Y	Y	Y	Y
15/04/92	-	Y	Y	Y	Y
15/05/92	-	Y	Y	Y	Y
07/06/92	-	Y	Y	Y	Y
01/08/92	-	Y	Y	Y	Y
30/09/92	-	Y	Y	Y	Y
28/10/92	-	Y	Y	Y	Y
24/11/92	-	Y	Y	Y	Y
09/01/93	-	Y	Y	Y	Y
28/01/93	-	Y	-	Y	Y
24/02/93	-	Y	-	Y	Y
12/03/93	-	Y	-	Y	Y
29/04/93	-	Y	-	Y	Y
06/06/93	-	Y	-	-	Y
26/07/93	-	-	-	Y	Y
19/08/93	-	Y	-	Y	Y
18/09/93	-	Y	-	Y	Y
05/11/93	-	Y	-	Y	Y
16/12/93	-	Y	-	-	Y
30/01/94	-	Y	-	Y	Y
08/03/94	-	Y	-	Y	Y
28/04/94	-	Y	-	Y	Y
26/05/94		Y		Y	Y

Appendix III: Peace Arm elk relocations - March 1991 through June 1994.
(Page 1 of 4)

Frequency	Date	Location	Easting	Northing	Elevation	% Slope	Aspect	Forest Cover	Comments
148.505	**3/2/91**	**Williston Lake**	**5332**	**62213**	**2500**	**18**	**240**	**shrub/grass**	
148.505	3/5/91	Williston Lake	5348	62210	2800	24	250	shrub/grass	
148.505	3/19/91	Williston Lake	5360	62208	2600	18	180	shrub/grass	
148.505	5/2/91	Williston Lake	5321	62234	2800	24	220	shrub/grass	
148.505	5/15/91	Williston Lake	5328	62223	3000	18	195	shrub/grass	
148.505	5/29/91	Dunlevy Inlet	5373	62216	2800	12	140	A-210	
148.505	6/10/91	Williston Lake	5299	62244	2800	18	200	shrub/grass	
148.505	6/25/91	Williston Lake	5350	62207	2400	30	180	shrub/grass	
148.505	7/11/91	Williston Lake	5358	62207	2500	40	180	A-110	
148.505	8/19/91	Williston Lake	5306	62256	3700	6	130	NSR-burn	
148.505	9/26/91	Dunlevy Inlet	5355	62215	3150	10	110	PIA-531	
148.505	10/8/91	Williston Lake	5329	62250	3600	12	190	NSR-burn	
148.505	10/17/91	Williston Lake	5346	62213	2900	20	210	A-110	
148.505	10/29/91	Williston Lake	5299	62248	3000	12	210	A-521	
148.505	11/14/91	Williston Lake	5333	62212	2600	30	180	A-110	
148.505	11/26/91	Williston Lake	5331	62213	2500	20	200	shrub/grass	
148.505	12/13/91	Aylard Creek	5293	62243	2400	24	140	shrub/grass	
148.505	12/28/91	Williston Lake	5320	62221	2500	30	220	A-110	
148.505	2/3/92	Williston Lake	5304	62238	2300	18	170	A-110	
148.505	2/20/92	Williston Lake	5289	62244	2800	24	180	shrub/grass	
148.505	3/14/92	Williston Lake	5346	62208	2500	30	180	shrub/grass	
148.505	4/15/92	Williston Lake	5335	62211	2500	24	190	shrub/grass	
148.505	5/15/92	Williston Lake	5296	62248	2700	36	220	shrub/grass	
148.505	6/7/92	Aylard Creek	5279	62240	2400	12	140	A-110	
148.505	8/1/92	Williston Lake	5308	62243	2400	30	200	A-110	
148.545	**3/2/91**	**Williston Lake**	**5332**	**62213**	**2500**	**18**	**240**	**shrub/grass**	
148.545	3/5/91	Williston Lake	5357	62208	2600	6	180	pine	
148.545	3/19/91	Williston Lake	5343	62211	2600	24	160	shrub/grass	
148.545	5/2/91	Williston Lake	5340	62215	3100	18	170	API-210	
148.545	5/15/91	Dunlevy Inlet	5377	62222	2900	10	120	A-210	
148.545	5/29/91	Dunlevy Inlet	5385	62218	2500	12	120	A-210	
148.545	6/10/91	Dunlevy Inlet	5384	62215	2500	12	130	aspen	
148.545	6/25/91	Dunlevy Inlet	5384	62226	2700	12	90	A-210	
148.545	7/11/91	Williston Lake	5365	62207	2400	40	180	A-110	
148.545	8/19/91	Dunlevy Inlet	5419	62267	3400	6	240	PISw-420	
148.545	9/26/91	Dunlevy Inlet	5385	62221	2600	20	90	A-210	
148.545	10/8/91	Dunlevy Inlet	5389	62217	2300	12	120	A-210	
148.545	10/17/91	Dunlevy Inlet	5389	62219	2400	12	100	A-210	
148.545	10/29/91	Tompkins	5418	62219	3100	10	300	A(Sw)-521	
148.545	11/14/91	Tompkins	5409	62193	2200	nil	flat	API-531	
148.545	11/26/91	Tompkins	5423	62207	2800	12	180	A-110	
148.545	12/13/91	Dunlevy Inlet	5393	62248	2700	30	240	A-210	
148.545	12/28/91	Williston Lake	5369	62211	2600	6	180	A-210	
148.545	2/3/92	Williston Lake	5354	62207	2900	18	180	shrub/grass	

148.545	2/20/92	Williston Lake	5376	62211	2500	12	170	A-420	
148.545	3/14/92	Williston Lake	5346	62208	2500	30	180	shrub/grass	
148.545	4/15/92	Williston Lake	5344	62210	2500	18	170	shrub/grass	
148.545	5/15/92	Williston Lake	5339	62209	2600	18	170	shrub/grass	
148.545	6/7/92	Williston Lake	5380	62217	2700	12	140	A-220	
148.545	8/1/92	Tompkins	5404	62226	2400	24	180	A-110	
148.545	9/30/92	Butler Ridge	5417	62266	3350	10	110	PIA-531	
148.545	10/28/92	Butler Ridge	5420	62217	3100	nil	flat	A(Sw)	
148.545	11/24/92	Tompkins	5419	62220	3100	18	300	A-531	
148.545	1/9/93	Dunlevy Inlet	5390	62249	2500	36	260	A-220	
148.565	**3/2/91**	**iVilliston Lake**	**5327**	**62216**	**2400**	**12**	**170**	**shrub/grass**	
148.565	3/5/91	Williston Lake	5348	62210	2800	24	250	shrub/grass	
148.565	3/19/91	Williston Lake	5325	62221	2700	24	200	shrub/grass	
148.565	5/2/91	Williston Lake	5328	62222	3000	24	180	shrub/grass	
148.565	5/15/91	Williston Lake	5332	62223	3000	18	170	shrub/grass	
148.565	5/29/91	Dunlevy Inlet	5376	62228	3000	12	80	Sw/A/Cot	
148.565	6/10/91	Dunlevy Inlet	5353	62226	3400	6	120	PIA	
148.565	6/25/91	Dunlevy Inlet	5357	62206	2400	25	180	shrub/grass	
148.565	7/11/91	Williston Lake	5360	62206	2500	40	180	A-110	
148.565	8/19/91	Dunlevy Inlet	5383	62221	2600	18	100	A-210	
148.565	9/26/91	Dunlevy Inlet	5369	62239	3050	10	80	SwACot-530	
148.565	10/8/91	Dunlevy Inlet	5370	62230	3100	6	90	Sw/A/Cot	
148.565	10/17/91	Williston Lake	5346	62213	2900	20	210	A-110	
148.565	10/29/91	Dunlevy Inlet	5380	62212	2500	12	150	A-210	
148.565	11/14/91	Williston Lake	5333	62217	2800	30	190	A-110	
148.565	11/26/91	Williston Lake	5340	62211	2600	20	180	shrub/grass	
148.565	12/13/91	Aylard Creek	5293	62243	2400	24	140	shrub/grass	
148.565	12/28/91	Williston Lake	5332	62219	2500	24	220	A-110	
148.565	2/3/92	Williston Lake	5304	62239	2400	18	170	A-110	
148.565	2/20/92	Williston Lake	5342	62210	2500	18	180	shrub/grass	
148.565	3/14/92	Williston Lake	5346	62208	2500	30	180	shrub/grass	
148.565	4/15/92	Williston Lake	5332	62212	2500	24	200	shrub/grass	
148.565	5/15/92	Williston Lake	5325	62218	2600	18	180	A-110	
148.565	6/7/92	Dunlevy Lake	5378	62226	3000	12	90	A-220	
148.565	8/1/92	Williston Lake	5352	62219	3100	nil	flat	PI-320	
148.565	9/30/92	Dunlevy Lake	5349	62238	3300	nil	flat	PIA-531	
148.565	10/28/92	Dunlevy Lake	5354	62221	3250	nil	flat	A(PI)	
148.565	11/24/92	Williston Lake	5341	62214	2900	18	140	shrub/grass	
148.565	1/9/93	Williston Lake	5327	62223	3000	20	180	shrub/grass	
148.565	1/28/93	Williston Lake	5320	62238	2900	18	270	A-210	
148.565	2/24/93	Williston Lake	5319	62236	2800	30	170	shrub/grass	
148.565	3/12/93	Williston Lake	5313	62232	2500	18	180	shrub/grass	
148.565	4/29/93	Williston Lake	5329	62222	2900	25	180	shrub/grass	
148.565	7/26/93	Williston Lake	5331	62237	3500	10	220	meadow	
148.565	8/19/93	Dunlevy Lake	5359	62238	3200	6	80	PI-320	
148.565	9/18/93	Dunlevy Lake	5369	62238	3100	12	90	imm. PI/A	
148.565	11/5/93	Williston Lake	5314	62234	2700	18	200	shrub/grass	

148.565	1/30/94	Williston Lake	5319	62223	2500	24	220	shrub/grass	
148.565	3/8/94	Williston Lake	5325	62223	2900	20	200	shrub/grass	
148.565	4/28/94	Williston Lake	5349	62209	2800	12	210	Shrub/grass	
148.565	5/26/94	Dunlevy Inlet	5390	62219	2300	6	100	A-320	
148.445	**3/16/91**	**Tompkins**	**5401**	**62203**	**2300**	**nil**	**flat**	**field**	
148.445	3/19/91	Dunlevy Inlet	5404	62243	3000	12	210	SwA	
148.445	5/2/91	Dunlevy Inlet	5409	62213	2400	18	260	SwACot-530	
148.445	5/15/91	Dunlevy Inlet	5431	62205	2700	6	160	A/Cot/Sw	
148.445	5/29/91	Dunlevy Inlet	5414	62206	2600	12	230	A-210	
148.445	6/10/91	Dunlevy Inlet	5414	62217	2800	12	270	A-110	
148.445	6/25/91	Dunlevy Inlet	5401	62195	2300	nil	flat	A-531	
148.445	7/11/91	Dunlevy Inlet	5418	62217	3100	12	270	A/Cot/Sw	
148.445	8/19/91	Dunlevy Inlet	5423	62263	3500	12	230	PIB-420	
148.445	9/26/91	Butler Ridge	5432	62225	3700	30	220	PIB-420	
148.445	10/8/91	Tompkins	5421	62216	3600	nil	flat	A/Cot/Sw	
148.445	10/17/91	Tompkins	5422	62214	3100	nil	flat	A/Cot/Sw	
148.445	10/29/91	Tompkins	5418	62219	3100	10	300	A(Sw)-521	
148.445	11/14/91	Tompkins	5412	62191	2200	nil	flat	API-531	
148.445	11/26/91	Tompkins	5410	62192	2200	nil	flat	API-531	
148.445	12/13/91	Tompkins	5413	62198	2300	nil	flat	A-631	
148.445	12/28/91	Tompkins	5444	62185	2300	nil	flat	ASw-531	
148.445	2/3/92	Tompkins	5426	62208	2800	12	180	A-210	
148.445	2/20/92	Tompkins	5453	62185	3000	30	200	shrub/grass	
148.445	3/14/92	Dunlevy Inlet	5406	62243	3000	12	180	SwPI	Shot in March 1992
148.585	**3/16/91**	**Tompkins**	**5401**	**62203**	**2300**	**nil**	**flat**	**field**	
148.585	3/19/91	Dunlevy Inlet	5411	62235	2600	12	150	A-110	
148.585	5/2/91	Dunlevy Inlet	5414	62197	2300	nil	flat	A-631	
148.585	5/15/91	Dunlevy Inlet	5419	62212	3100	6	180	A/Cot/Sw	
148.585	5/29/91	Dunlevy Inlet	5433	62208	2900	12	180	API-210	
148.585	6/10/91	Dunlevy Inlet	5426	62202	2600	18	190	shrub/grass	
148.585	6/25/91	Dunlevy Inlet	5404	62200	2300	nil	flat	field	
148.585	7/11/91	Dunlevy Inlet	5419	62212	3100	12	260	A/Cot/Sw	
148.585	8/19/91	Dunlevy Inlet	5438	62229	3200	24	350	SwB-831	
148.585	9/26/91	Butler Ridge	5434	62243	4000	30	220	PIB-420	
148.585	10/8/91	Butler Ridge	5433	62242	4000	18	220	PIB-420	
148.585	10/17/91	Tompkins	5423	62215	3100	nil	flat	A/Cot/Sw	
148.585	10/29/91	Yacht Club	5434	62186	2300	nil	flat	ASw-531	
148.585	11/14/91	Tompkins	5408	62193	2200	nil	flat	API-531	
148.585	11/26/91	Tompkins	5408	62193	2200	nil	flat	API-531	
148.585	12/13/91	Tompkins	5413	62198	2300	nil	flat	A-631	
148.585	12/28/91	Tompkins	5434	62187	2300	nil	flat	field	
148.585	2/3/92	Tompkins	5426	62208	2800	12	180	A-210	
148.585	2/20/92	Tompkins	5453	62185	3000	30	200	shrub/grass	
148.585	3/14/92	Dunlevy Inlet	5406	62243	3000	12	180	SwPI	
148.585	4/15/92	Dunlevy Inlet	5424	62207	3100	6	180	A-631	
148.585	5/15/92	Dunlevy Inlet	5419	62209	2900	30	190	A-110	
148.585	6/7/92	Dunlevy Inlet	5408	62265	2300	nil	flat	A-220	

148.585	8/1/92	Tompkins	5451	62219	3600	30	160	PISw-520	
148.585	9/30/92	Tompkins	5436	62216	3300	10	190	API-631	
148.585	10/28/92	Tompkins	5413	62298	3200	18	210	A(PI)	
148.585	11/24/92	Tompkins	5422	62215	3100	nil	flat	A-531	
148.585	1/9/93	Tompkins	5410	62200	2300	nil	flat	A-530	
148.585	1/28/93	Tompkins	5435	62221	3400	10	250	ASw-531	
148.585	2/24/93	Tompkins	5407	62214	2400	nil	flat	ASW-631	
148.585	3/12/93	Tompkins	5409	62197	2300	nil	flat	field	
148.585	4/29/93	Tompkins	5423	62211	3000	10	180	shrub/grass	
148.585	6/6/93	Tompkins	5418	62219	3000	15	270	A-631	
148.585	7/26/93	Tompkins	5418	62214	2600	10	270	A-631	
148.585	8/19/93	Tompkins	5437	62215	3200	6	180	A-631	
148.585	9/18/93	Butler Ridge	5462	62225	4000	18	180	API	
148.585	11/05/93	Tompkins	5432	62212	3100	12	190	A-631	
148.585	12/16/93	Tompkins	5418	62217	3100	12	270	A-631	
148.585	1/30/94	Tompkins	5417	62212	3100	18	260	A-631	
148.585	3/8/94	Tompkins	5414	62239	2600	10	250	Sw/Cot	
148.585	4/28/94	Tompkins	5424	62212	3000	6	180	A-220	
148.585	5/26/94	Tompkins	5433	62218	3300	nil	flat	A-631	